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Intensity of Time and Income Interdependent Multidimensional Poverty: Well-Being Gap and Minimum 2DGAP – German Evidence

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Abstract

This paper focuses on the interdependent multidimensional (IMD) poverty intensity of time and income. We introduce a two (and more) dimensional poverty gap measure, hereafter called the minimum multidimensional poverty 2DGAP, an appealing, integrated measure of interdependent multidimensional poverty severity (compensation approach, weak focus axiom). The minimum 2DGAP allows disentangling the intensity of each single poverty attribute by ensuring multidimensionality and quantifies as a unique solution an efficient way to escape multidimensional poverty.

Our multidimensional poverty approach in addition to income includes time as a fundamental resource for any activity. We first propose genuine personal leisure time as the time dimension which respects social participation/social inclusion aspects for poverty in the sense of Armatya Sen's capability approach. The interdependence of multidimensional (IMD) time and income poverty is estimated by a CES-type well-being function whose parameters are novel evaluated by satisfaction data of the German population and not arbitrarily chosen as in the literature.

The empirical application is based on the German Socio-Economic Panel (SOEP) and the German Time Use Studies (GTUS) 1991-92 and 2001-02. Our findings are a new contribution to the poverty situation of the "working poor" with results for the minimum poverty 2DGAP as well as for multidimensional Foster-Greer-Thorbecke type measures (strong and weak focus axiom) of poverty risk and well-being poverty gap.

With Heckman type estimates we answer two questions: First, what drives the IMD poverty risk and the minimum poverty 2DGAP, and second, have uni- and multidimensional time and income poverty risk and poverty gap to be differently explained. One result: it is not an additive mix of unidimensional influences but an explanation of its own which characterizes the multidimensional case

All empirical results indicate the overall importance of the time dimension with its social participation aspect in particular being incorporated in an interdependent multidimensional time and income poverty approach. An important dimension would be neglected in poverty analysis and in targeted poverty policies if time is not respected in addition to income.

JEL: I32, D31, J22

Keywords: *Intensity of interdependent multidimensional time and income poverty, union and compensation approach, minimum multidimensional poverty gap (2DGAP), extended economic well-being, satisfaction/happiness, working poor, CES well-being function, German Socio-Economic Panel, German Time Use Surveys 1991-92 and 2001-02*

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1 Introduction

Extending the traditional income poverty concept by multidimensional poverty has been of growing interest within the last years (see an overview by Kakwani and Silber 2008). Multidimensional poverty in most applications is empirically measured by a list of given activities an individual is excluded from (see the discussion by Nolan and Whelan 2007). Within the counting approach (Atkinson 2003, Alkire and Foster 2011), the aggregation to a poverty index relies on the number of dimensions[3] which people are deprived of.[4] But any interdependencies between the dimensions are either neglected or arbitrarily weighted. Our concern, however, is to allow interdependency between multiple poverty dimensions when analysing the intensity of multidimensional poverty.

This paper analyses the interdependence of multidimensional time and income poverty. The trade-off, the substitution/compensation between time and income will be captured by a CES-type well-being function within multidimensional Foster-Greer-Thorbecke type measures of poverty risk and severity. Though our CES well-being function is only slightly different to ones already proposed (Bourguignon and Chakravarty 2003, Lugo and Maasoumi 2008, 2009), the empirical evaluation of the substitution by satisfaction data of the total German population which does not assume arbitrarily different trade-off situations is novel.

We introduce a two dimensional poverty gap measure, hereafter called the minimum multidimensional poverty 2DGAP, an appealing, integrated measure of multidimensional poverty severity, which allows disentangling the intensity of each single poverty attribute by ensuring multidimensionality. The 2DGAP, a mapping to the space of the single poverty dimensions, quantifies as a unique solution an efficient way to escape multidimensional poverty.

With our study of multidimensional poverty intensity, we argue that, beyond traditional income, time as a prominent and basic resource necessary for any activity is an important well-being and poverty dimension. Concerning time we first propose genuine personal leisure time as an important poverty dimension since it allows social participation and social inclusion, following Amartya Sen's capability approach.

The new empirical application for Germany is based on the German Socio-Economic Panel (SOEP) with its individual satisfaction data for the CES well-being function estimation and on the German Time Use Studies (GTUS) 1991-92 and 2001-02 with its detailed time use diary data for all further empirical analyses. We provide results for the minimum poverty 2DGAP as well as for multidimensional Foster-Greer-Thorbecke (FGT) type measures (strong and weak focus axiom) of poverty risk and well-being poverty gap. Our findings are a new contribution to the poverty situation of the "working poor", a social important and growing group at least for Germany (Rhein 2009).

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[3] Such as a car, TV, washing machine, or whether people can do certain things like going on holidays, having friends, having a substantial meal regularly etc.

[4] The European Union Laeken social inclusion indicator set is an example of multiple poverty dimensions with educational disadvantages, health inequalities, unemployment and worklessness as poverty dimensions (Atkinson 2003).

Two emerging questions are answered in this study by Heckman type multivariate estimates: First, what drives the IMD poverty risk and the minimum poverty 2DGAP, and second, have uni- and multidimensional time and income poverty risk and poverty gap to be differently explained on the individual level.

The study is structured as follows: At first, multidimensional poverty concepts are discussed and the intensity of interdependent multidimensional (IMD) poverty is defined under the strong (union approach) and weak focus axiom (compensation approach). Then CES-type well-being based multidimensional, Foster-Greer-Thorbecke (FGT) type measures of poverty risk and gap are characterized. The minimum 2DGAP concept is introduced and discussed in Section 2. Section 3 justifies time and income as the multiple poverty dimensions and presents CES well-being function estimates (SOEP data) for a population wide multiple poverty line evaluation. After characterizing the German Time Use Surveys 1991-92 and 2001/2002, Section 4 presents prominent time and income unidimensional and interdependent multidimensional poverty intensity FGT and minimum 2DGAP results and its dynamics for the active German population (GTUS data). Then the questions about the explanation of uni- and multidimensional poverty risk and poverty intensity are answered by Heckman type selectivity correction estimates. The last section concludes and summarizes the main contribution of the study.

2 Measuring Multidimensional Poverty

In the unidimensional context, poverty indices based on certain desirable axioms have been discussed and available for long time (see e.g. Zheng 1997, Chakravarty and Muliere 2004) with some consensus about the empirical value of the poverty threshold as a certain percentage of an equivalized household income, say. In the multidimensional context, axiomatic based poverty indices are a more recent development (see Tsui 2002, Bourguignon and Chakravarty 2003, Chakravarty and Silber 2008 as well as the survey by Chakravarty 2009). Poverty thresholds there might be considered for each dimension as well as for their combination, yet the discussion and the more empirical application is still in its infancy.

2.1 Multidimensional Poverty Axiomatic

The majority of unidimensional poverty axioms were transferred to the multidimensional level: the poverty axioms of symmetry, monotonicity, continuity, principle of population, scale invariance and subgroup decomposability (Bourguignon and Chakravarty 2003, p. 29, Maasoumi and Lugo 2008, p. 5). The focus axiom in the multidimensional context, however, has to be discussed separately.

The focus axiom in the unidimensional context claims that a poverty index has to be independent of non-poor persons' quantities. Within the multidimensional context two different approaches for the focus axiom are conceivable. On the one hand, the multidimensional focus axiom could demand that the multidimensional poverty index be independent of quantities lying above the single dimension thresholds. On the other hand, it could only be required that the index be independent of non-multidimensional poor persons' quantities. The former requirement is called the *strong focus axiom*, while the latter is named *weak focus axiom* (Bourguignon and Chakravarty 2003). The consideration of these two axioms corresponds to the question whether a deprivation in one dimension could be compensated by the quantities above dimension threshold in another dimension. The weak focus axiom allows such a substitution for all poverty ranges while the strong focus axiom does not for all poverty ranges.

Moreover, in the multidimensional case, it is debatable whether a so-called correlation increasing switch should raise or reduce the multidimensional poverty index. A correlation increasing switch is a change of quantities between two multidimensional poor persons in a deprived dimension that increases the correlation between dimensions. After such a switch, strong deprivation in one dimension is increasingly attended by strong deprivation in the other dimension. Depending on the relationship between poverty dimensions, one could expect an increase or a decrease of the multidimensional poverty index.

Assuming a substitutive relation between dimensions, one would rather expect an increase, since strong deprivation in one dimension could not increasingly be compensated by the other dimension quantity. The corresponding axiom is the *non-decreasing poverty under correlation increasing switch* (Bourguignon and Chakravarty 2003, p. 31). Given a complementary relationship between dimensions, one would rather expect a decrease, since compensation is not at all possible. Accordingly, a decline in one dimension of an individual that is strongly deprived in the other does not additionally worsen the individual situation. Here, the corresponding axiom could be called *non-increasing poverty under correlation increasing switch*. Normally, one expects at least a limited substitutional relationship. Therefore, the former axiom is predominantly found in the literature (e.g. Tsui 2002, p. 78). The respective correlation situation for our analysis is described in Section 2.3.

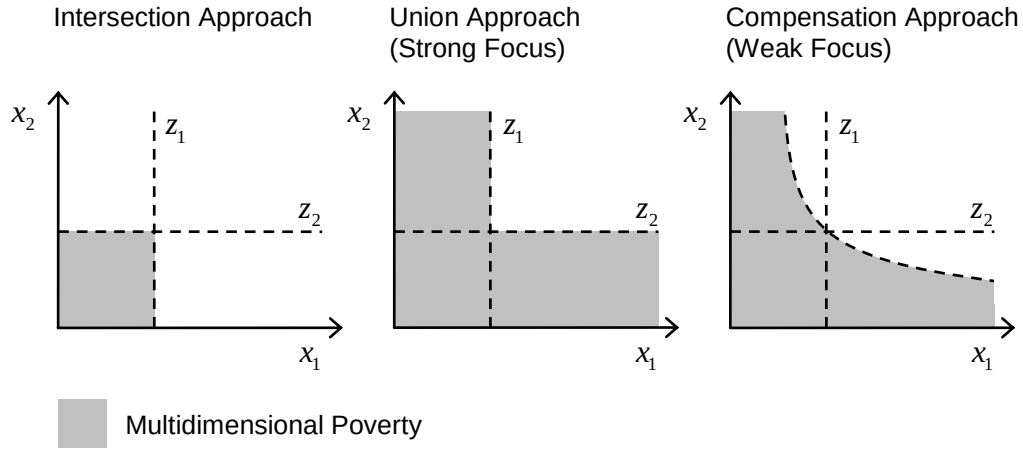
2.2 Multidimensional Poverty Concepts: Identification

In principle multidimensional poverty concepts and axioms require the definition of two kinds of thresholds for the identification of multidimensional poor individuals. On the one hand, poverty thresholds for each poverty dimension are needed to count the number of deprived dimensions for each individual. On the other hand, one has to determine in how many dimensions an individual would have to be deprived in order to be judged multidimensional poor. Here two extreme approaches can be distinguished. Following the so called *union approach (strong focus axiom)*, a person is judged to be multidimensional poor as soon as he or she is deprived in one single dimension (see Figure 1 for the two dimensional case). The *intersection approach*, in contrast, only judges an individual to be multidimensional poor when she or he is deprived in all dimensions. Intermediate concepts are conceivable as well (see e.g. Alkire and Foster 2007 as well as Atkinson 2003 who mention this case).

The selection of the union or intersection approach as the identification strategy depends on the relationship between poverty dimensions. This raises the fundamental question whether a substitution/compensation between poverty dimensions is possible. Given a substitutive situation, the intersection approach seems to be more adequate. There the deficit in one dimension might be compensated by the other. Given a complementary interaction between poverty dimensions and that the deprivation in one dimension might not be compensated by the other attribute, then the union approach would be more appropriate (see e.g. Atkinson 2003, Leßmann 2009).

Against this background the issue arises whether at least a limited substitution should be considered in the identification of a poor person. In the vast majority of cases, poverty dimensions are neither perfect substitutes nor perfect complements but something between these two extremes. Accordingly, the deficit in one dimension might be compensated to a limited extent and with diminishing returns by the other attribute. Union and intersection approaches as identification strategies seem to be too rigid for most cases (Bresson 2009, p. 2; Lugo and Maasoumi 2009, p. 25).

Figure 1: Identification of Multidimensional Poverty with the Intersection, Union and Compensation Approach in the Two-Dimensional Case



Note: x_1 and x_2 are the quantities of the first and second dimension while z_1 and z_2 are the corresponding poverty dimension thresholds.
Source: Own figure

The empirical question is whether and to which extent a poverty gap in one dimension might be compensated by higher quantities in the other dimension. If a gap in one dimension can be compensated by the other dimension quantity above the dimension threshold, then a person is off poverty. If such a gap cannot be compensated by another dimension quantity, then the person will be called multidimensional poor. We will call such an approach as the *compensation approach (weak focus axiom)* because substitution/compensation is allowed for all ranges in one dimension given poverty in the other dimension. In the compensation approach mainly applied in the following, not only the number of deprived dimensions but also the extent of poverty gaps and the size of quantities above dimension thresholds for the poverty identification and poverty intensity are respected (see the right picture in Figure 1 for the two dimensional case).

Because substitution/compensation is allowed in the compensation approach (weak focus property) as well (but limited to the intersection approach) as in the union approach we will call this poverty situation *interdependent multidimensional poverty* (IMD poverty).

Considering then the multidimensional poverty line (based on two dimensions as in Figure 1), there is general agreement that an individual who is deprived in both dimensions should be judged to be multidimensional poor, while an individual who is not deprived in any dimension should not be judged to be multidimensional poor. Accordingly, a multidimensional poverty line that accounts for at least limited substitution and diminishing returns has to run through the intersection of the dimension thresholds (z_1,z_2) in Figure 1.

2.3 Multidimensional Poverty Indices: Headcount Ratio and Multidimensional Poverty Gaps

After identifying multidimensional poor individuals in the previous section, the question is how to capture the extent of poverty, i.e. the intensity of poverty, within a multidimensional poverty index. In the unidimensional context the Sen-Shorrocks-Thon (SST index)[5] or the

[5] See Osberg and Xu 2002 based on Sen 1997, Shorrocks 1997, Thon 1979,1983

Foster-Greer-Thorbecke 1984 (FGT) indices are well-known. In the case of the unidimensional FGT index, the individual poverty function is

$$(1) \qquad p_i = \max\left[\frac{z - Y_i}{z}; 0\right]$$

measuring the poverty gap as a relative deviation of the well-being indicator Y_i (income, say) to the defined poverty threshold z. The aggregation of all individuals yields the unidimensional FGT poverty index

$$(2) \qquad P(Y,z) = \frac{1}{n}\sum_{i=1}^{n}(p_i)^{\alpha} = \frac{1}{n}\sum_{i=1}^{n}\left[max\left(\frac{z - Y_i}{z}; 0\right)\right]^{\alpha},$$

where α indicates the poverty risk aversion: the higher the parameter, the more sensitive the index is to strong deprivations. For α = 0, the headcount ratio results, α=1 corresponds to the poverty gap and α=2 represents a quadratic poverty gap.

In the multidimensional context in particular Lugo and Maasoumi 2009 as well as Bourguignon and Chakravarty 2003 embrace all (two) dimensions in their multidimensional poverty indices. Lugo and Maasoumi 2009 attempt to transfer the unidimensional FGT index to the multidimensional framework. They classify two aggregation approaches: one by "shortfall of well-being" (aggregate poverty line approach) and one by "well-being of the shortfalls"[6] (component poverty line approach). Both of them might be analyzed under the strong or weak focus poverty axiom. The first one relies on individual well-being compared to well-being at the threshold intersection, where well-being is measured as the output of a production type well-being function with two (or more) input factors allowing substitution. In the second one, the relative differences between the individual dimensional attributes and their thresholds are the respective input factors of the well-being function.

Based on the available data in our empirical application, we will evaluate the individual income and time situation in levels and accordingly concentrate on the "shortfall of well-being" approach, with levels rather than with relative deviations as arguments in the well-being function. Though accounting for combined well-being, with our proposed minimum multidimensional poverty gap indicator (2DGAP, see next section), we also isolate the single dimensional attributes when we disentangle them within the multidimensional context.

The interdependence of the single poverty attributes within the individual well-being indicator V_i^* by Lugo and Maasoumi (2009, pp. 12, 16) and Bourguignon and Chakravarty (2003, p. 38) is captured there by a constant elasticity of substitution (CES) type function as

$$V_i^* = \left[w_1\left(x_i^1\right)^{\beta} + w_2\left(x_i^2\right)^{\beta}\right]^{\frac{1}{\beta}},$$

where β describes the level of substitutability with $\beta = 1$ for perfect substitution and $\beta = \infty$ for non-substitutes.[7] Similar to them but with a slightly more flexible CES-type well-being function our individual well-being indicator V_i evaluates the interdependencies of both poverty dimensions as:

[6] Which corresponds to the Bourguignon and Chakravarty 2003 multidimensional poverty index.

[7] Calvo 2008 as well uses a CES-like specification in his study of vulnerability to multidimensional poverty.

CES well-being function:

$$(3) \qquad V_i = \gamma\left[w_1 \left(x_i^1\right)^{-\rho} + w_2 \left(x_i^2\right)^{-\rho} \right]^{\frac{\upsilon}{-\rho}} \qquad \textit{weak focus axiom}$$

and

$$(4) \qquad V_i = \gamma\left[w_1 \left(\min\left[x_i^1, z^1\right]\right)^{-\rho} + w_2 \left(\min\left[x_i^2, z^2\right]\right)^{-\rho} \right]^{\frac{\upsilon}{-\rho}} \qquad \textit{strong focus axiom}$$

with the substitution elasticity $\sigma = 1/(1+\rho)$, ρ as a curvature parameter of the isopoverty contours with $\rho \neq 0$, γ as a constant[8], υ as returns to scale, x_i^1 and x_i^2 as the input (poverty attribute) quantities and z^1 and z^2 as the thresholds of the first and second poverty dimension, and the input coefficients w_1 and $w_2 = 1 - w_1$ as distribution and weighting parameters describing the skewness of the isopoverty contours.

Why use such a CES-type well-being function? Within the CES well-being function substitution/compensation is possible between all levels of the poverty dimensions. Constant elasticity in general assumes that any poverty attribute pair, like our time and income pair, are held together by its degree of substitution regardless of the level of well-being. However, substitution is different between different rays from the origin which allow different substitutions when the relation of time and income, say, is changing; a quite flexible assumption.[9]

Beyond the substantial meaning of the constant γ as some basic log (well-being) within the later econometric specification and the returns to scales υ as showing the effects from a proportional change in all inputs (where all inputs increase by a constant factor), our CES well-being function will provide a better goodness of fit within the empirical estimation (see Section 3.3).

Note that the arguments in the strong focus case (min(.)) restrict the input levels to their poverty lines, which is not the case under the weak focus property. Accordingly, under strong focus axiom a substitution between input factors is not possible above the dimension thresholds (see Figure 2). However, and as mentioned above, under the weak focus axiom substitution is possible in all regimes below the multidimensional isopoverty threshold.

The *multidimensional poverty line*

$$(5) \qquad V_z = \gamma\left[w_1 \left(z^1\right)^{-\rho} + w_2 \left(z^2\right)^{-\rho} \right]^{\frac{\upsilon}{-\rho}}$$

is the aggregate poverty line under the weak and strong poverty axiom. It is the isopoverty contour crossing the threshold intersection (see Figure 2).

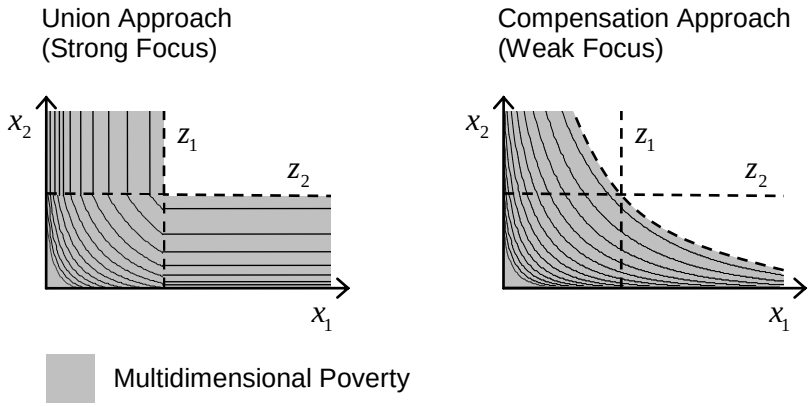
The *multidimensional poverty function* similar to the unidimensional FGT poverty measure but now as a relative gap of individual well-being to the multidimensional threshold well-being is

$$(6) \qquad p_i = \max\left[\frac{V_z - V_i}{V_z}; 0 \right].$$

[8] In the production function discussion it is some technical progress indicator.

[9] See further discussion, interpretation and justification for CES in Merz and Rathjen 2009.

Figure 2: Interdependent Multidimensional Isopoverty Contours - Union Approach (Strong Focus) and Compensation Approach (Weak Focus) in the Two-Dimensional Case



Note: x_1 and x_2 are the quantities of the first and second dimension while z_1 and z_2 are the corresponding dimension thresholds.
Source: Own figure

The aggregated (across individuals) multidimensional FGT poverty measure corresponding to Lugo and Maasoumi 2009 then is

$$(7) \qquad P(V,z) = \frac{1}{n}\sum_{i=1}^{n}(p_i)^{\alpha} = \frac{1}{n}\sum_{i=1}^{n}\left[max\left(\frac{V(z) - V(x_i^1, x_i^2)}{V(z)}, 0 \right)\right]^{\alpha} \quad weak\ focus\ axiom$$

and

(8)

$$P(V,z) = \frac{1}{n}\sum_{i=1}^{n}(p_i)^{\alpha} = \frac{1}{n}\sum_{i=1}^{n}\left[max\left(\frac{V(z) - V\left[\min(x_i^1, z^1), \min(x_i^2, z^2)\right]}{V(z)}, 0 \right)\right]^{\alpha} \quad strong\ focus\ axiom$$

with $\alpha = 0$ delivering the multidimensional headcount, $\alpha = 1$ an average relative poverty gap in well-being units applied to the total population which measures poverty intensity, and $\alpha > 1$ respecting a higher aversion against strong deprivations.

The multidimensional FGT poverty measures for strong and weak focus fulfils the axioms under the constraint, of course, that the compensation approach (weak focus) does not satisfy the strong focus axiom (Lugo and Maasoumi 2009).

The multidimensional FGT with our CES well-being function further fulfils *non-decreasing poverty under correlation increasing switch* (Bourguignon and Chakravarty 2003, p. 31) if $\alpha \geq -\rho$ (assuming $\upsilon = 1$), respectively, fulfils *non-increasing poverty under correlation increasing switch* if $\alpha \leq -\rho$ (assuming $\upsilon = 1$).

2.4 Minimum Multidimensional Poverty Gap (Minimum 2DGAP) - A Mapping to the Single Dimensional Space

The IMD poverty concept discussed above relies on well-being units when comparing the individual situation with the aggregated IMD poverty line evaluated by the population, say. In the weak focus case, which is more closely examined in the following, all dimensions are combined and weighted via the respective CES well-being function. Figure 3 (top) accordingly describes the well-being mountain with V_z as the well-being level at the threshold isopoverty line and V_i an individual well-being level. The difference between V_z and V_i is the multidimensional poverty well-being gap under discussion.

Minimum Multidimensional Poverty Gap (Minimum 2DGAP) – Concept, Condition and Properties

A mapping of the well-being dimension to its (two) single dimensional space allows another appealing integrated approach to describe multidimensional poverty severity. It is again a distance between the individual situation and the poverty line but a unique distance which provides the contribution of the single poverty attributes within the interdependent multiple approach. This distance is an additional straightforward possibility to concisely measure the individual multidimensional poverty situation and to disentangle its single poverty attributes while at the same time ensuring the interdependence of all poverty dimensions.

Consider the two dimensional case by the compensation approach by its attributes space as in Figure 3 and regard the poverty situation at (x_1,x_2) for an individual. With respect to both dimensions there is a fan of distances from that point (x_1,x_2) to the IMD isopoverty line. Each distance yields the same well-being difference V_i - V_z (third dimension). However, each distance requires different single attribute input intensities to be overcome in order to escape multidimensional poverty.

One distance is prominent: it is the *shortest* path between (x_1, x_2) and the corresponding point (p_1,p_2) at the isopoverty contour which requires the minimum input intensities in a sense of a minimum combined input "length". A natural measure for that length is the Euclidian distance of the single attributes $c = (a^2 + b^2)^{0.5}$ with the distances a and b as single poverty attribute gap intensities (see Figure 3).

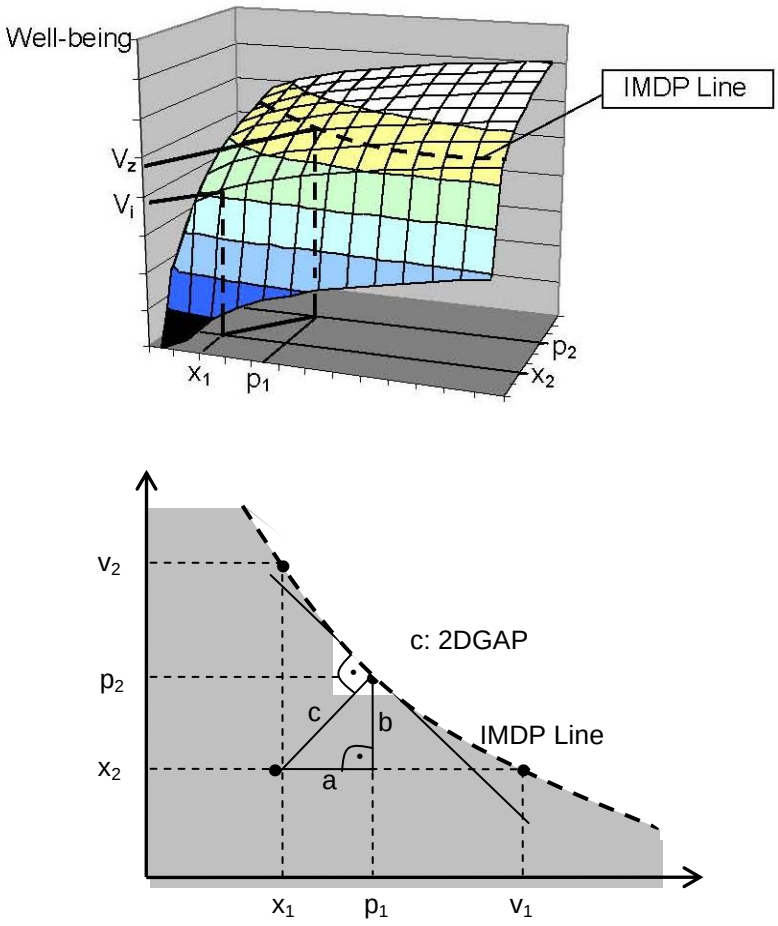
The solution for the shortest (or closest) length then is characterized by the orthogonal path from the IMD tangent at (p_1,p_2) to (x_1,x_2).[10] We will call the distance c the minimum multidimensional poverty 2DGAP (for two poverty dimensions), which is the measurable two dimensional minimum mapping of the well-being distance between the individual and the aggregate isopoverty well-being contours.

Minimum 2DGAP definition and property: For any point (x_1,x_2) in the two dimensional poverty space under the weak focus CES-type isopoverty line, the minimum multidimensional poverty gap with two poverty dimensions, minimum 2DGAP, is defined as the linear path which is orthogonal to the slope at the respective point (p_1,p_2) on the CES-type isopoverty line. Since the proposed CES well-being function is well behaved, there is always a unique solution for the minimum 2DGAP (distance c).

[10] Though Lugo and Maasoumi (2008, p. 14, 2009, p. 12) mention a distance from the individual point to the isopoverty line as the 'closest point' at the isopoverty line in the multidimensional case, they do not determine any further characteristics and properties of that distance.

As the shortest length of the combined input intensities to overcome the poverty gap, the distance might be called the efficient way to escape poverty respecting both dimensions based on multidimensional well-being.

Figure 3: Multidimensional Poverty Well-Being Gap and Minimum 2DGAP as a Mapping onto its Dimensions



Source: Own figure

Minimum 2DGAP calculation: To calculate the minimum 2DGAP distance c, the coordinates (p_1,p_2) at the isopoverty line have to be found that fulfil the condition of being the shortest distance to/from (x_1,x_2). There are different ways to calculate the distance c. This can be achieved by an iterative procedure of changing distances to find the shortest distance c in the interval $[x_1,v_1]$, where v_1 is the coordinate of the isopoverty line at x_2. An alternative method is an iterative procedure of changing slopes until the slope of the isopoverty line is orthogonal to the slope of the linear function through (x_1,x_2). In addition, the minimum of the non-linear function $c=(a^2+b^2)^{0.5}$ which incorporates the slope of the isopoverty contour might be found by any algorithm for minimizing a function.[12]

[12] The minimum 2DGAP Stata algorithm is available from the authors by request.

***Minimum NDGAP**:* The minimum 2DGAP can be extended to the n-dimensional case, called minimum NDGAP, by a multivariate minimum search where the slopes of the linear distance are subject to the orthogonality of all slopes of the n dimensional tangents to the isopoverty contour. A conceivable minimum 3DGAP for example would have to consider three dimensional isopoverty contours and a two dimensional tangent plane resulting in a minimum 3DGAP fan which is rectangular to the tangent plane.

The Benefit: Visibility of Single Attributes of Multidimensional Poverty

The minimum 2DGAP distance c measures the shortest multidimensional gap as the shortest length of all dimensional gap intensities in combined attribute units but so far with no direct interpretation in the money or in the time space. However, and this is the benefit in particular of our proposal, both sides of its rectangular triangle (the distances a and b of Figure 3), are measurable and interpretable in their single dimension, say income and time. Thus, beyond the compact interdependent multidimensional poverty description by minimum 2DGAP there is the additional single dimension feature, as its single unidimensional attributes are visible by the two sides a and b of the minimum 2DGAP triangle (Figure 3), with a as the amount of the first and b as the amount of the second attribute in its genuine dimensions to efficiently leave poverty while respecting the interdependency and its substitution/compensation.

In our application this would be income in money units (€) for a, and time in time units (minutes) for b as the attributes to escape multidimensional poverty in an efficient manner.

Relative 2DGAP and Aggregation

The 2DGAP might be defined as a relative measure as relative to the maximum 2DGAP distance (cmax), which is the distance from the origin to the respective orthogonal slope at the IMD isopoverty line:

$$\text{Relative 2DGAP} = \text{2DGAP}/\max(\text{2DGAP})$$

with its corresponding single relative single poverty attribute gap intensities (amax and bmax).

For aggregation purposes the individual absolute or relative minimum 2DGAPs (NDGAPs) and their single multidimensional attributes might be cumulated and characterized by their means and other statistics. The aggregated respective minimum components to c, and the single dimensional companions a and b then provide a comprehensive multidimensional poverty picture and in its disentangled components under interdependency.[13]

3 Application: Intensity of Time and Income Interdependent Multidimensional Poverty – The Case of Germany

Our empirical application of the intensity of interdependent multidimensional poverty in Germany will focus on time and income as prominent poverty attributes. Before the empirical poverty intensity investigation for Germany in 1991-92 and a decade later in 2001-02 we first

[13] The aggregation of the single poverty attributes a and b and of the 2DGAP c over all individuals might not result in the joint aggregate condition $c = (a^2 + b^2)^{0.5}$. With two degrees of freedom the residual component is computable from the other aggregates. As our applied results will show, alternative computations yield similar aggregate results.

justify and define the two poverty dimensions selected, income and time, and present the CES well-being results for the multidimensional poverty threshold.

3.1 Applied Income Poverty Concept

Income allows the acquisition and consumption of goods and services and is regarded as a general resource indicator to describe individual well-being and is traditionally used as a dominant poverty dimension. Since household members generally share their (net) income with other household members, the unit of observation is commonly the household with household net income as the joint disposable income for consumption activities. To compare various households of different structures with different needs and household size effects, a net equivalence income is used within the poverty discussion and in our subsequent analyses. The net equivalence income then equates the household net income divided by the sum of equivalence weights to all household members. Internationally, the OECD established a new scale. It assigns – as we will do – a weight of one to the household head, a weight of 0.5 to additional household members aged 15 years or older and a weight of 0.3 to all others.

Based on such an equivalized income, the majority of conventional income-based poverty concepts in the European Union judge a person as income poor if net equivalence income is below 60% of the median net equivalent income of all individuals (Bundesregierung 2005, XV). This concept is adopted in the present study. Accordingly, income poverty occurs with a position left of the equivalized income poverty line in Figure 4.

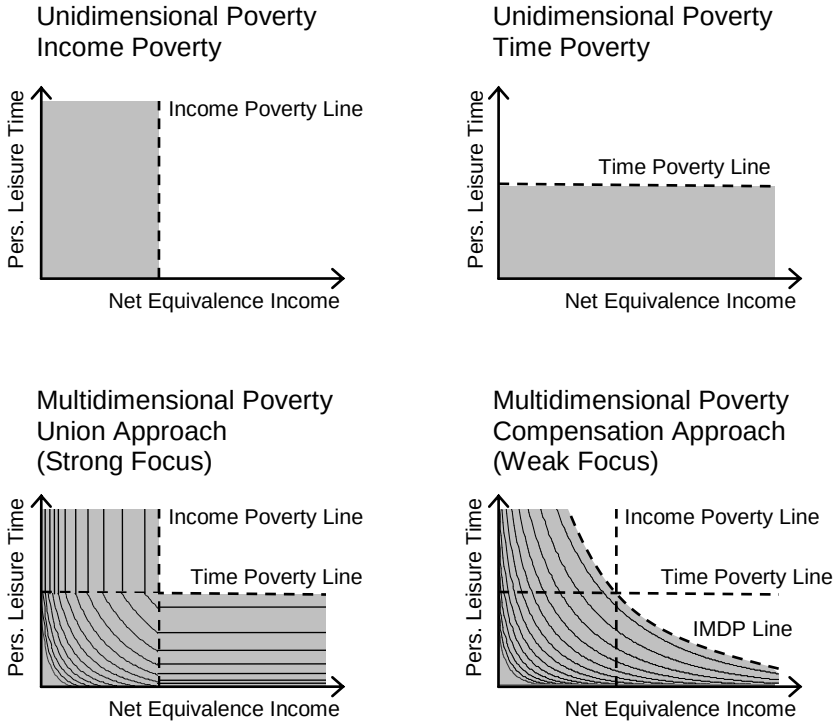
For Germany recent empirical income inequality and income poverty results can be found e.g. in Groh-Samberg 2009, Hauser 2008, Merz 2008, Becker and Hauser 2003 or Hauser und Becker 2000. In contrast to our analysis, the focus there and in the empirical German poverty literature, however, is restricted to the unidimensional income based poverty concept.

3.2 Applied Time Poverty Concept

Time in general is necessary for any activity and is a fundamental prerequisite enabling and restricting daily living activities. Time affects individual well-being either by time stress and its various consequences (qualitative aspect) or simply by restricting activities being important for individual well-being (quantitative aspect). Whereas income is the broadly accepted and overwhelmingly applied dimension in poverty analyses, time is rarely recognized as a poverty dimension. Yet Vickery 1977 or Harvey and Mukhopadhyay 2007 highlight the importance of considering non-market time in poverty analyses in general and in their time poverty analyses in particular. Burchardt (2008, p. 11-14) discusses a broad range of economic, social and social policy arguments for regarding time in addition to income. The focus of her time and income poverty study with several case studies is individuals who are limited by time *as well as* income constraints; trade-offs between both poverty attributes are beyond her focus. Calvo 2008 analyses vulnerability to multidimensional poverty (under the strong focus axiom), considering the uncertainty of the dimensional states. His poverty dimensions are consumption and leisure, where leisure is broadly defined within the empirical application for Peru[14] assuming severe deprivation of leisure time when work is beyond 8 h. Bardasi and Wodon (2006, p. 84) in their study of time poverty in Guinea define their time poverty line as 1.5 time (and 2 times) the median of the total individual working hours distribution.

[14] Total weekly time minus 7 h of daily sleep minus 8 h daily work.

Figure 4: Time and Income Unidimensional and Interdependent Multidimensional Poverty Concepts



Source: Own figures

We intend to embrace the social participation and social inclusion/exclusion aspect by expanding the income poverty dimension by the time poverty dimension.[16] In particular, together with further economic and social perspectives, we argue that time (beyond income) is an elementary poverty dimension since any social participation requires time. This corresponds to Sen's (e.g. 1999, 1985) extended perspective on poverty, because time, similar to a commodity, can be seen as a basic condition needed to accomplish any functioning to achieve the capability set with its respective freedom of choice. The link of leisure time and social participation is also articulated by Bittman 1999: "The ability to participate in [social life] […] is the product of both access to leisure goods and services, and a sufficient quantity of leisure time."

In contrast to a total or broad leisure time concept, we argue that time poverty is present when the remaining personal leisure time, what we call genuine personal leisure time, is below a certain level and no or only restricted time is left for social participation. We will define genuine personal leisure time as the remaining available time left after all responsibilities/obligations such as labour time, household working time, childcare, household requirements, sleeping, personal care and health activities have been carried out. There is no doubt that social participation is also possible during some of these activities. However, an individual's situation is aggravated when all obligations and duties for daily living – enjoyable or not, voluntary or not – are completed and no time is left for that genuine personal leisure.

[16] The economic implications of social cohesion are discussed e.g. in Osberg 2003.

Similar to our time approach, but still different, is the distinction between free time and discretionary time made by Goodin, Rice, Bittman and Saunders, 2005, or Goodin, Rice, Parpo and Eriksson, 2008. For these authors free time is the actual time left over after carrying out 'obligatory' activities such as paid work, unpaid work and personal care. Since more than necessary time might be spend for those 'obligatory' activities, Goodin and colleagues therefore define "discretionary time" as the residual after the minimum necessary time was spent for paid and unpaid work and personal care. In contrast to the discretionary time approach we prefer to incorporate an appropriate direct time consuming activity, i.e. genuine personal leisure time, rather than try to determine the 'necessary time' and then the discretionary time hidden in each single activity, which would also be hard to discover empirically.

The household situation is the basis for traditional income orientated poverty analyses. Similarly, the question arises whether time poverty should be considered in the household context as well. We argue that genuine personal leisure time could not, or only to a very limited extent, be reallocated between household members, and is thus strictly linked to the individual. Thus, we regard time poverty at the individual level.

As a definition of time poverty, Bittman (1999, p. 14) suggests a median concept similar to the traditional income orientated poverty concepts: "A commonly employed standard used to benchmark [income] poverty [..] is 50 per cent of the median. [..] Applying an analogous standard (50 per cent of the median leisure time) […] we can get some idea of what social situation produces the most severe kinds of time poverty". Adopting this concept but according to EU standards, we use the 60% median time poverty line, however, in reference to the individual situation and according to genuine personal leisure. Therefore, genuine personal leisure time poverty will occur with a position under the time poverty line as in Figure 4.

3.3 Applied Interdependent Multidimensional Time and Income Poverty Concept: CES Well-Being

Why should we care about for the interdependence of time and income? Time is restrictive for all activities and requires an activity allocation within a day, a week or other time period. Market time to achieve income is competing in a time period with time for other non-market activities including our genuine personal leisure time. The more time is spent for income gaining purposes, the less is available for leisure and vice versa.

This is the well known microeconomic perspective which highlights our central argument by providing an answer to the question how time is to be allocated in an optimal sense. Maximizing a well-being (utility) function with consumption and leisure as arguments subject to the time constraint yields the optimal allocation of time for consumption (respective labour supply for its necessary income) and leisure. Depending on the shape of the well-being function, the degree of the substitution/compensation, i.e. the trade-off between labour and leisure time, can be determined within the optimal solution of the constrained utility maximization problem.[17]

In our case total leisure time is divided into genuine personal leisure and further leisure time. So there are two candidates within total leisure time for the compensation of income activities. One might argue that personal leisure time is the first candidate for compensation since

[17] Both time and income are also crucial in the extended Becker 1965 household production model. There a household maximizes the utility of final commodities which are produced in the household out of market goods and time.

further household responsibilities require more or less fixed time. However, how the compensation/substitution between working hours and personal leisure is to be quantified depends on the respective well-being function, a task for further empirically based well-being estimates.[18]

How is the interdependent multidimensional time and income poverty threshold empirically determined? As already mentioned, we specify the IMD poverty line (compensation approach, weak focus axiom) by a CES-type well-being function as in Equation (3). In contrast to others (like Bourguignon and Chakravarty 2003 or Lugo and Maasoumi 2009) who arbitrarily choose the dimension weights in their empirical applications, our CES well-being function will be empirically estimated and population based. This empirically based estimation needs a well-being indicator. A suitable indicator is individual satisfaction, for which data is available in the German Socio-Economic Panel (SOEP, see Wagner, Frick and Schupp 2007), our evaluation data base.

Our evaluation of individual well-being by satisfaction data refers to the recent happiness/satisfaction literature (Frey and Stutzer 2005, 2002, Clark et al. 2008), with its direct measures of satisfaction about quality of life aspects.[19] Interpersonal utility comparisons are critically discussed at least in economics. Yet, van Praag and Ferrer-i-Carbonell 2008 in particular provide some convincing arguments for measuring well-being by survey questions about satisfaction, as we will do. The happiness and capability approaches are discussed in detail and brought together by Sen 2008 in the volume edited by Bruni, Comim and Pugno (2008).

CES function econometrics

Using the SOEP reported general life satisfaction 11-point scale[20] for estimating individual well-being requires something like an ordered response modelling. However, as is well-known from production function estimation, the Kmenta 1967 Taylor series approach allows a simple OLS estimator of the log transformed non-linear CES well-being function of Equation (3) as

$$(9) \qquad \ln V = \ln \gamma + \upsilon\delta \ln I + \upsilon(1-\delta)\ln L - \frac{1}{2}\rho\upsilon\delta(1-\delta)\left[\ln I - \ln L\right]^2 + \varepsilon$$

providing efficient estimates. Some further conditions are fulfilled in our estimation and discussed in Merz and Rathjen 2009.

Specifying our CES relationship of Equation (3) with personal genuine leisure time L and net equivalence income I (in 2002 prices) as inputs and reported general life satisfaction V_i as the proxy for the multidimensional well-being, the CES well-being function for 2002 is estimated as:

$$(9) \qquad V_i^{2002} = 3.550\left(0.519\, I_i^{\,0.297} + 0.481 L_i^{\,0.297}\right)^{\frac{0.108}{-0.297}}$$

with its contours as isopoverty lines as in Figure 5. Poverty should be evaluated by a population. Our CES well-being function estimates take the active population into account with the

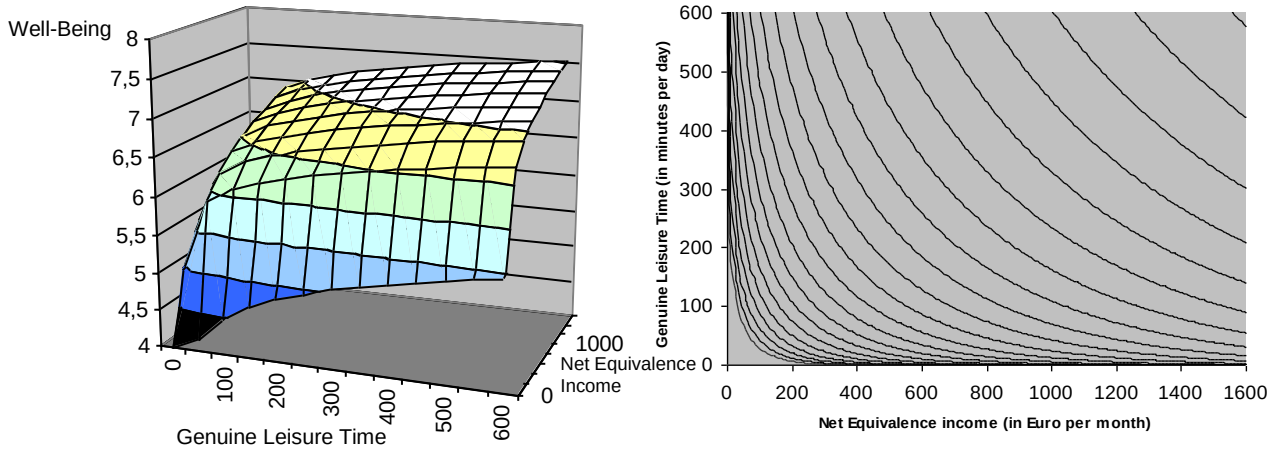
[18] For a further discussion of time and income see also Bonke, Deding and Lausten 2009, Hamermesh and Pfann 2005 with discussions on the economics of time use and Merz 2002 on time use and economic well-being.

[19] For a critical discussion about subjective outcomes in economics and satisfaction as an economic variable see Hamermesh 2004 and Freeman 1978.

[20] SOEP 2002 question 11 in the personal questionnaire.

argument that the active population in particular actually experiences work and leisure and therefore might better judge the trade-off between work and leisure than the non-active population.

Figure 5: Estimated CES Utility Function – Well-Being and Isopoverty Contours



Source: Own estimation with GSOEP 2002, daily working hours > 5

In general, within a CES function the degree of substitution measured by the substitution elasticity might range from perfect substitution ($\rho = -1, \sigma = \infty$) over a certain degree of substitution (including the Cobb-Douglas case with ($\rho = 0,\ \sigma = 1$) to no substitution at all (complementary input factors, $\rho = \infty, \sigma = 0$). The estimated and population based evaluated substitution/compensation between genuine time and income of $\sigma = 1.422$ is a bit less distinct than in the Cobb-Douglas type ($\sigma = 1$) situation. Thus it is a bit easier to substitute time by income than in the Cobb-Douglas case. The returns to scale with $\upsilon = 0.108$ mean that a doubling of the inputs time and income will raise well-being by around 7%. Significant estimated coefficients together with the fulfilment of further consistency rules quantify and support the relevance of the substitution/compensation between time and income (see Figure 5).

The estimated CES well-being function fulfils the *non-decreasing poverty under correlation increasing switch* axiom for the multidimensional FGT measures with $\alpha = 0$, $\alpha = 1$ and $\alpha = 2$ as well as the further poverty axioms presented above.

Why do we take the CES estimates of 2001-02 for the evaluation of 1991-92 as well? The reason is that we need a common comparison standard for the evaluation of both periods.[21] Note that all 1991-92 money measures will be deflated by the 2001-02 price index for comparison reasons as well.

When is an individual to be judged as interdependent multidimensional poor? According to the union approach (under the strong focus axiom), an individual is multidimensional poor if their net equivalence income or (logical or) their genuine leisure time is below the 60% me-

[21] The original CES estimates for 1991-92 result in $V_i^{1992} = 3.673\left(0.670\, I_i^{\,0.280} + 0.330\, L_i^{\,0.280}\right)^{\frac{0.097}{-0.280}}$ with a larger weight for income and a reduced substitution elasticity of σ=1.389 compared to the 2001-02 CES estimates, which highlights the increased weighting and substitutability of time by the German population during that decade.

dian of all persons. Here, multidimensional poverty occurs with a position under the time poverty line or left of the income poverty line as in Figure 4.

Which isopoverty contour (indifference curve) of Figure 5 should be the *aggregated IMD poverty* line (under the weak focus axiom, compensation approach) to assign individuals to be multidimensional poor? As mentioned above, a person who is neither time nor income poor should not be judged multidimensional poor in either of the interdependent approaches, the compensation as well as the union approach. Judging individuals as multidimensional poor, i.e. poor in both dimensions, is likewise revealing. Accordingly, the interdependent multidimensional poverty line should run through the intersection (z_1,z_2) of the unidimensional time and income poverty thresholds (see also Figure 4).

A person then is assigned to be *interdependent multidimensional poor* (IMD poor compensation approach (weak focus axiom) if their poverty attributes are below the IMD isopoverty line. Note that this is regardless of any voluntary or non-voluntarily individual well-being situation; as in common poverty analyses an individual is counted to be poor if (s)he is just below the defined poverty line.

To summarize, in the compensation approach, the IMD poverty line is an isopoverty contour as in Figure 5; in the union approach it is the boundary line of the time and income poverty rectangles as in Figure 4 (lower left picture).

4 Time and Income Interdependent Multidimensional Poverty Intensity – The German Case

Since appropriate well-being data are only available in the German Socio-Economic Panel (SOEP) we use the SOEP for the CES well-being evaluation discussed above. Though in principle we could use the SOEP for our further analyses we prefer to use in addition time use diary data from both German Time Use Surveys (GTUS) from 1991-92 and 2001-02 (with no appropriate well-being information) since the time use diaries provide additional in-depth information. In particular only the diaries provide information about the time spent with others (social participation) and daily explanatory/background variables used in the estimation of poverty determinants (like detailed daily working hour arrangements with its timing and fragmentation of working hours).

In the *German Time Use Surveys* participants were asked to note their daily routines in diaries in their own words three times during the week, two working days and a Saturday or Sunday. In addition to the diaries, which were coded afterwards, the participants completed a personal and a household questionnaire. For 1991-92 6,774 households with 15,366 persons and 30,732 diaries are available. In 2001-02 5,144 households with 11,908 persons and 35,685 diaries are available. For a detailed description of the German Time Use Surveys see Ehling 1999, Ehling, Holz and Kahle 2001 as well as Ehling 2003.

Income and income poverty are measured as monthly household net equivalence income as described in the previous section. For comparison reasons all subsequent income information for 1991-92 is adjusted to 2001-02 prices.

Time and time poverty is measured as personal genuine leisure time. This time information, provided in detail by the individual time use diaries, include activities that are allocated to one of the main categories “Contact, Conversations, Sociality” and “Media Use, Free-time Activities” in GTUS 1991-92, or the categories “Social Life and Entertainment”, “Participation in

Athletic Activities e.g. Outdoor Activities", "Hobbies and Games" and "Mass Media" in GTUS 2001-02.

By incorporating the use of mass media, such as watching television, into the personal leisure time, a relatively high median and the poverty threshold for personal genuine leisure time can be expected. However, the use of mass media has become an essential part of personal leisure activity and an activity with familial social participation.

4.1 Time, Income and Interdependent Multidimensional Poverty Thresholds

The empirical base for the single time and poverty thresholds is the entire population with its active and non-active parts.[22] Including the non-active population for defining the thresholds is commonly used and thus ensures comparability with other poverty analyses.[23] The single poverty thresholds then are parts of the multidimensional poverty threshold.

The single *income poverty thresholds* for Germany are €665.8 for 1991-92 and €793.55 for 2001-02 (see Table 1 and Figure 6), an increase within that decade by 19.2 %. Note that all income data are adjusted for price inflation.

The single *genuine personal leisure time poverty* lines are 159 minutes for 1991-92 and 186 minutes for 2001-02, an increase by about 17%.

Table 1: Income, Time and Interdependent Multidimensional Poverty Line

	1991-92	2001-02	Difference %
Median Net Equivalence Income (in € per month and 2002 prices)	1109.64	1322.58	19.2
Median Personal Leisure Time (in minutes per day)	265	310	17.0
Income Poverty Line (= 60% median net equivalence income)	665.78	793.55	19.2
Time Poverty Line (= 60% median personal leisure time)	159	186	17.0
$V^{poor} = f(I^{poor}, L^{poor})$	6.704	6.827	1.8

Source: Own calculations with GTUS 1991-92 and 2001-02. The time and income poverty lines by GTUS data are calculated for the total population.

The evaluated *IMD poverty threshold* at the intersection of the unidimensional time and income thresholds is about a well-being level of 6.704 in 1991-92 and 6,827 in 2001-02 based on the parameter estimates of the 2002 SOEP data:

$$(10) \qquad V_{1992}^{poor} = f(I^{poor}, L^{poor}) = 3.550 \cdot \left(0.519 \cdot 665.78^{0.297} + 0.481 \cdot 159^{0.297}\right)^{\frac{0.108}{0.297}} = 6.704$$

$$(11) \qquad V_{2002}^{poor} = f(I^{poor}, L^{poor}) = 3.550 \cdot \left(0.519 \cdot 793.55^{0.297} + 0.481 \cdot 186^{0.297}\right)^{-\frac{0.108}{-0.297}} = 6.827 .$$

[22] Remember, the GSOEP CES well-being function was evaluated by the active population only to better capture the trade-off between work and leisure.

[23] If only the active population would be considered the income poverty would increase considerably.

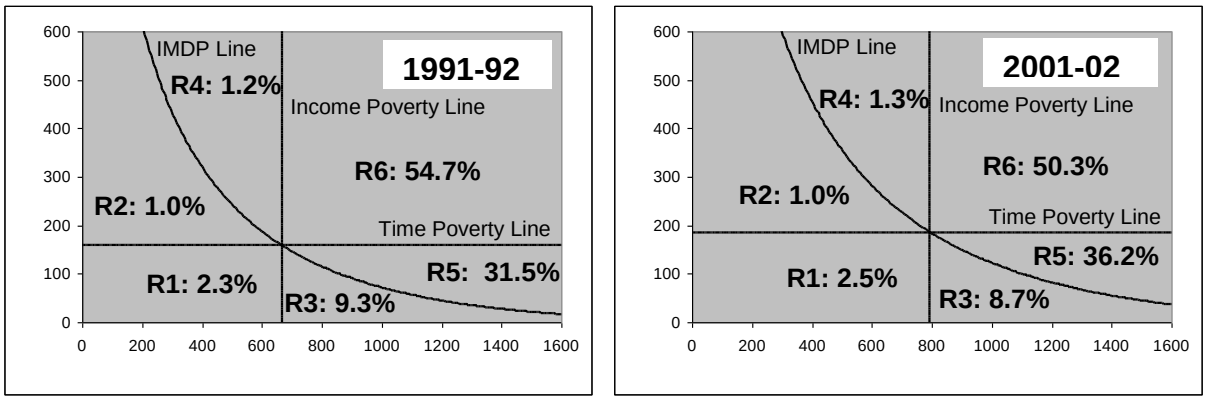
As mentioned above, for comparison reasons the 1991-92 well-being function is specified by the same estimated parameters as in 2001-02. The CES results suggest a slight increase in overall well-being within the ten-year period. The estimated input coefficients, the weight w for income and $(1-w)$ for personal leisure, indicate a certain dominance of income. However, the evaluated time contribution is not far away from a balanced 50-50% situation and refers to the importance of the time dimension as evaluated by the German population.

4.2 Overall Intensity of Uni- and Multidimensional Time and Income Poverty

Whereas the respective poverty thresholds rely on the active and non-active population, the following poverty intensity analyses concentrate on the active population.[24] With a focus on the active population our poverty analyses accentuate the situation of the working poor, a population group of growing interest and importance at least in the German labour market discussion.[25]

Given the empirical thresholds, each GTUS sample person then belongs to one of six multidimensional poverty regimes out of Figure 6, where each regime will provide specific interesting results. Figure 6 illustrates the IMD headcount ratios (Foster-Greer-Thorbecke (FGT) measure with α=0) in different poverty regimes for both years. Table 2 provides the overall multidimensional FGT results including their uni- and multidimensional well-being poverty gaps with their respective standard errors and 95% confidence intervals for both years too.[26]

Figure 6: Interdependent Multidimensional and Unidimensional Poverty Thresholds and Headcount Ratios in Different Poverty Regimes for Germany 1991-92 and 2001-02



Source: Own calculations with GTUS 1991-92 and 2001-02, active population; total population for the calculation of median income, individuals older than 11 years for the calculation of median personal leisure time

Intensity of Unidimensional Income Poverty (Active Population): From 1992 to 2002 the percentage of income poor active individuals (headcount ratio / FGT index with α = 0) marginally but not significantly increases from 4.5% to 4.8% (see Table 2 and Figure 6, regimes

[24] With more than 5 daily working hours (similar to the SOEP 2002 estimation) to avoid part-time situations with less restricted total leisure time.

[25] The working poor (even) refers to a working poor household which the individual under investigation belongs to and not necessary to a working poor person himself.

[26] The FGT with α=1 provides relative mean poverty gaps. Further absolute mean interdependent multidimensional and unidimensional time and income poverty gaps are given in Merz and Rathjen 2011

1, 2, 4). Results for the FGT index with α=1 suggest an increasing poverty gap intensity within the ten-year period. The corresponding poverty index – measuring the average (relative) poverty gap – increases significantly (α=5%) from 0.00797 to 0.01067.[27] Respecting a larger poverty aversion, however, results in a non-significant increase (FGT, α=2).

Intensity of Unidimensional Time Poverty (Active Population): From 1992 to 2002 the percentage of time poor active individuals (headcount ratio / FGT index (α = 0)) significantly (α=1%) increases from 43.3% to 47.4% (see Table 2). The time poverty level is remarkably high. The reason is that although we focus on the active population, the non-active population with its relative high leisure time is determining a relative high time poverty threshold yielding a relative high time poverty ratio.[28]

The unidimensional time poverty gap measured by the FGT index with α=1 slightly increases from 0.17586 to 0.18522 while the FGT index with α=2 remains relative constant over the ten-year period; the one percentage point increase is significant if a 5.9% significance level is accepted. The higher the poverty aversion, the smaller thus is the 1992 to 2001 difference in the poverty gaps.

Table 2: Interdependent Multidimensional and Unidimensional Time and Income Poverty 1991-92 and 2001-02, Germany

		1991-92				2001-02				Diff. Test[1]
		Index	Std. Err.	95% Conf. Interval		Index	Std. Err.	95% Conf. Interval		p-values
FGT[2] (α=0)	Unidimensional									
	Income	0.04523	0.00262	0.04010	0.05036	0.04816	0.00342	0.04145	0.05487	0.49648
	Time	0.43338	0.00614	0.42133	0.44542	0.47357	0.00721	0.45943	0.48771	0.00002***
	Multidimensional									
	Union (SF)	0.45193	0.00650	0.43920	0.46466	0.49702	0.00745	0.48241	0.51163	0.00001***
	Compensation (WF)[3]	0.12588	0.00421	0.11764	0.13413	0.12159	0.00459	0.11260	0.13058	0.49099
FGT (α=1)	Unidimensional									
	Income	0.00797	0.00063	0.00674	0.00921	0.01067	0.00092	0.00885	0.01248	0.01548*
	Time	0.17586	0.00329	0.16941	0.18230	0.18522	0.00371	0.17795	0.19248	0.05911
	Multidimensional									
	Union (SF)	0.01264	0.00033	0.01198	0.01329	0.01254	0.00032	0.01191	0.01317	0.82780
	Compensation (WF)	0.00406	0.00020	0.00367	0.00445	0.00378	0.00021	0.00336	0.00419	0.33433
FGT (α=2)	Unidimensional									
	Income	0.00290	0.00030	0.00231	0.00349	0.00352	0.00038	0.00277	0.00427	0.20038
	Time	0.10501	0.00261	0.09989	0.11013	0.10434	0.00273	0.09898	0.10970	0.85921
	Multidimensional									
	Union (SF)	0.00088	0.00004	0.00079	0.00097	0.00073	0.00004	0.00065	0.00081	0.00802***
	Compensation (WF)	0.00029	0.00002	0.00025	0.00034	0.00027	0.00002	0.00022	0.00032	0.47953

[1] Difference in means test (unequal unknown variances), significance levels: *=α<5%, **= α<1%, ***= α<0.1%
[2] FGT = Forster-Greer-Thorbecke measure [3] WF=weak focus axiom

Source: Own calculations with GTUS 1991-92 and 2001-02, active population

[27] Note small figures are due to the FGT type division by the total population number and not by the number of poor people.

[28] The similar argument holds for the relatively low income poverty ratio: The non-active population with no labour income diminishes the income poverty threshold which yields a lower income poverty ratio.

Intensity of the Multidimensional Poverty (Union Approach, Strong Focus Axiom): According to the *union approach (strong focus axiom)*, the percentage of multidimensional poor individuals significantly increases from 45.2% in 1992 to 49.7% in 2002 (see Table 2). Note that the relatively high levels depend on incorporating all regimes under both dimensional thresholds (in particular inclusive regime 5, a compensation regime under weak focus). The gap intensity indices of FGT with α=1 (FGT1) are slightly decreasing over the ten-year period (not significant), while the FGT index with α=2 (FGT2) significantly decreases (α=1%).

Intensity of Multidimensional Poverty (Compensation Approach, Weak Focus Axiom): According to the *compensation approach (weak focus axiom)* allowing a substitution between poverty dimensions also above the single dimension thresholds, the headcount ratios of the multidimensional poor individuals fall slightly but not significantly from 12.6% in 1992 to 12.2% in 2002; for both years yet a remarkable proportion of working poor. The FGT1 as well as the FGT2 index slightly decreases as well, but also not significantly.

Thus, though the headcount ratios of the union and the compensation approach differ in the development sign over the decade (+ in the union approach, - in the compensation approach), with all intensity measures of both multidimensional approaches however a decrease of the IMD poverty gap is indicated.

Poverty Regimes: Figure 6 illustrates the varying importance of poverty regimes according the headcount ratios. Interestingly, the prominent part of the IMD working poor are found in regime R3 with 9.3% (1991-92) and 8.7% (2001-02): there the time deficit is assigned not to be compensated even by above poverty income; a distinct evidence of the importance of time as a poverty dimension. Within that decade the assigned compensation of the time deficit by above poverty income increased from 31.5% to 36.2% (regime R5). For both years we face a core IMD poverty of persons being time as well as income poor (regime R1) with 2.3% in 1991-92 and slightly increased with 2.5% in 2001-02.

To summarize the overall picture: *unidimensional income and time poverty* show a poverty increase in Germany within the decade considered. This holds for the headcount ratio (not significant for income but for time) as well as for the mean relative poverty gap measured by FGT1 (significant both for income and time). *Multidimensional poverty* under the strong focus axiom (union approach) also significantly increased with regard to the headcount ratio but decreases significantly with regard to the intensity gap when poverty aversion is higher (FGT2). Multidimensional poverty under weak focus axiom, however, shows a slightly decreasing poverty picture with regard to the headcount ratio as well as to both gaps; the decade differences however are not significant.

The reason behind the different results under the strong and weak focus axioms: If compensation is not considered above the dimension thresholds (union approach, strong focus axiom), then regime R5 (time poor but not income poor and above IMD poverty line) affect a relatively high general headcount ratio which increased from 1991 to 2001 in particular because of an indeed relatively strong increase of just this regime. However, if compensation is considered (compensation approach, weak focus axiom), then regime R5, where the time deficit is to be compensated, is therefore no longer a multidimensional poverty regime and the relatively strong increase of regime R5 is not relevant any more. This even results in a slight but not significant decrease of the multidimensional IMD headcount ratio and in the sequel of all FGT gaps (compensation approach, weak focus axiom).

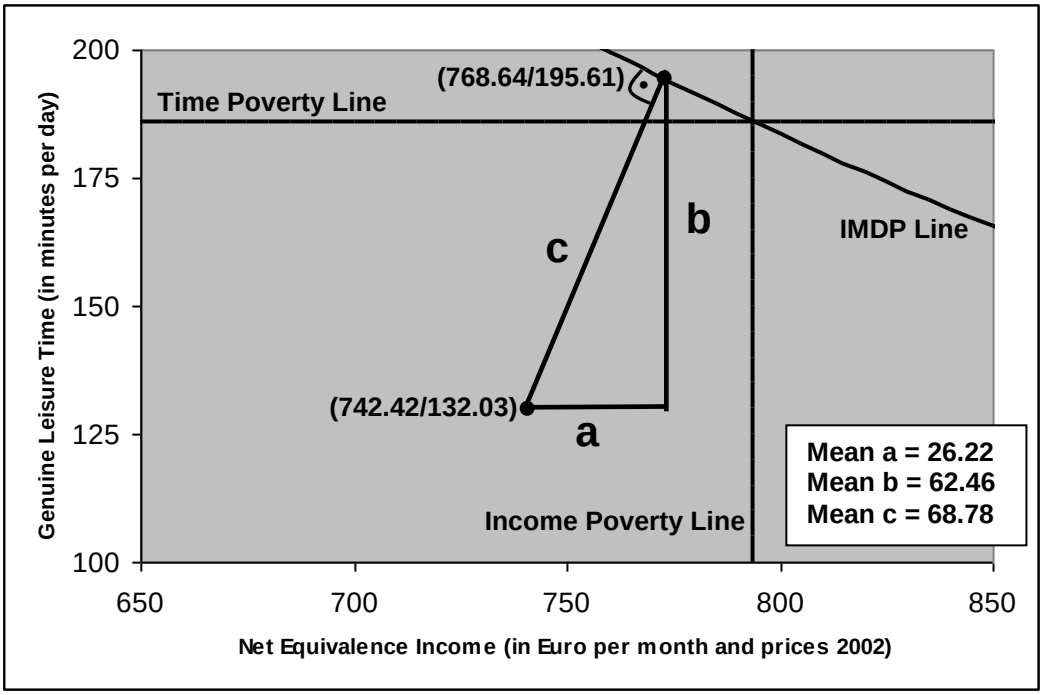
4.3 Minimum Multidimensional Poverty 2DGAP

The multidimensional poverty gap so far was measured in well-being units without any further information about its single attributes. Our proposed minimum multidimensional poverty 2DGAP provides additional information in the single time and income space and disentangles the interdependent poverty dimensions respecting substitution/compensation. As discussed, the minimum 2DGAP thus offers an effective way out of multidimensional poverty with information about its single attributes.

Figure 8 illustrates the situation for the mean situation of multidimensional poverty in Germany for 2001-02. The overall mean of all individual minimum 2DGAP distances c may be called a *centre of IMD poverty* (compensation approach, weak focus axiom). To fix this distance and line within the income and time space, one needs to know for each poor individual where this line will cross the IMD poverty contour.

By iteration with the mean distances a and c and the orthogonality condition then the unique position of c can be computed.[30]

Figure 8: Mean Minimum Multidimensional Poverty 2DGAP, 2001-02, Germany



Source: Own figure based on GTUS 2001-02, active population

Mean minimum multidimensional poverty 2DGAP: The result for Germany (Figure 8 and Tables 3a, b): The mean effective way out of multidimensional poverty respecting time and income 2001-02 is the distance c with 68.78 units (11.42% of the maximal distance starting at (0.0)) in 2002 which is significantly larger than in 1992 with 49.41 (8.20% of the maximal distance) units. In other words: the multidimensional poverty gap is significantly larger in 2001-02, the poverty severity increased significantly within that decade.

[30] Though the respective empirical means of a, b and c do not necessarily exactly satisfy the Pythagorean theorem at the mean values, the results are close.

Table 3a: Mean Minimum Multidimensional Poverty 2DGAP of Interdependent Multidimensional Time and Income Poverty 1991-92 and 2001-02, Overall, Germany

2DGAP	1991-921		2001-02		Diff.	Max 2DGAP
		%[1]		%	%[2]	
a Income [€]	17.80	4.10	26.22	6.04	47.30***	434.40
b Time {minutes]	45.14	1.,81	62.46	14.96	38.37***	417.51
c Minimum 2DGAP	49.41	8.20	68.78	11.42	39.20***	602.51

1 % of the maximum 2DGAP (distance from the origin to the point at the IMD isopoverty contour with orthogonal slope)

2 Relative differences 1991-92 to 2001-02; Difference in means test (unequal unknown variances), significance levels: *=α<5%, **= α<1%, ***= α<0.1%

Source: Own calculations with GTUS 1991-92 and 2001-02, active population

The mean minimum IMD poverty situation is characterized by a €742.42 income poverty gap and a 132.03 minutes time poverty gap. The mean minimum 2DGAP crosses the IMD poverty threshold at €768.64 and 195.61 minutes of genuine personal leisure time.

On average about €26 of income and a bit more than one additional hour of genuine personal leisure time is needed to escape multidimensional poverty (compensation approach, weak focus axiom) in 2001-02. Compared to 1991-92 both gap attributes are higher; within that decade it is going to be harder to escape multidimensional poverty in both dimensions (Tables 3a, b).

Interestingly, with regard to the importance of the single poverty 2DGAP attributes the time poverty gap (distance b) is comparably higher than the income poverty gap difference (distance a) in both years (measured as the Relative 2DGAP, the percentage distance to max 2DGAP) highlighting the particular strength of the time burden (Table 3a).

Poverty Regimes: The mean minimum 2DGAP as an overall description of the multidimensional poverty situation has its starting point in the core poverty regime (R1) highlighting the particular importance of the poverty intensity of the working poor being time *as well* income poor (Figure 8).

Further 2DGAP results for all single poverty regimes are provided in Table 3b. Within the decade being considered, the mean minimum 2DGAP increased overall by about 33%, flanked by all increased poverty regimes determining a growing multidimensional time and income poverty gap in Germany.
Within the IMD poverty regime R1, the core poor with time as well income poor people, the mean minimum 2DGAP increased significantly and at most by about 30%. This underlines again the severity of poverty in both time and income dimensions. To escape poverty there efficiently in 2001-02, one would need €72 (€21.5 more than 1991-92) and 133 minutes of genuine personal leisure time (40 minutes more than a decade earlier).

Table 3b: Mean Minimum Poverty 2DGAP by Poverty Regimes, 1991-92 and 2001-02, Germany

	2DGAP: c Mean Minimum 2DGAP			2DGAP: a Mean Minimum Income 2DGAP (in €)			2DGAP: b Mean Minimum Time 2DGAP (in minutes per day)		
	1991-92	2001-02	Diff.[1]	1991-92	2001-02	Diff.[1]	1991-92	2001-02	Diff.[1]

			%			%			%
R1	106.7176	152.5694	30.05	50.63491	72.17527	29.84	93.06684	133.5011	30.29
	(4.11026)	(5.19315)	***	(2.57724)	(3.31472)	***	(3.28085)	(4.13939)	***
R2	56.35211	75.12522	24.99	35.51656	46.75295	24.03	43.23462	58.26131	25.79
	(4.73298)	(7.16912)	*	(3.33438)	(5.01437)		(3.41206)	(5.19218)	*
R3	34.56861	44.34332	22.04	7.754112	10.81547	28.31	33.59079	42.87851	21.66
	(0.94883)	(1.33200)	**	(0.26549)	(0.40425)	***	(0.91438)	(1.27449)	***
IMD Poverty (R1+R2+R3)	49.4138	68.77621	33.03	17.80475	26.21514	32.08	45.1396	62.46745	33.21
	(1.33817)	(1.99812)	***	(0.75626)	(1.12071)	***	(1.13031)	(1.69233)	***

[1] Difference of means test (unequal unknown variances), significance levels: *=α<5%, **= α<1%, ***= α<0.1%

Source: Own calculations with GTUS 1991-92 and 2001-02, active population

IMD well-being vs. minimum 2DGAP poverty: The multidimensional FGT well-being gap measures (FGT1 and FGT2) show a slight but not significant decrease of multidimensional time and income poverty (compensation approach, weak focus axiom), whereas the 2DGAP results indicate a significant increase in the analysed decade for Germany. One reason for the different poverty gap indication: The well-being gaps cover a wide spread of paths between different well-being levels showing a cloudy gap picture. Compared to this, the distinguished and unique path based on the 2DGAP approach between two well-being levels lightens the cloud. We may conclude and propose: poverty gaps between two situations are similar only if both multidimensional well-being as well as minimum 2DGAP show no significant differences. However, as long as the multidimensional minimum 2DGAP indicates significant differences, multidimensional poverty gap differences should not be neglected.

4.4 What drives Time and Income Uni- and Multidimensional Poverty – Poverty Risk and Poverty Gap Microeconometric Estimation

Two important questions emerge after the above description of of uni- and multidimensional time and income poverty in Germany: First, what drives the IMD poverty risk and the minimum poverty 2DGAP, and second, have uni- and multidimensional time and income poverty risk and poverty gap to be differently explained on the individual level.

Since the respective poor are expected not to be a random subgroup of the entire population, respectively of the working population, we apply the Heckman (1976) approach to account for the expected selectivity. As known, the two step procedure with step1: PROBIT estimation for the probability to be IMD poor and step 2: selectivity correction estimates of the minimum 2DGAP allows a separate explanation of the probability of being selected, the poverty risk, and the amount of the variable of interest, the poverty gap.

Explaining poverty risk and poverty gap intensity can borrow from theoretical and empirical results in the literature but so far only concerning the unidimensional approach.

As to income and unidimensional income poverty with focus on the poverty risk at least for Germany most studies rely on univariate descriptive results (see e.g. Becker and Hauser 2003), multivariate results (like probit estimates) are rare. However, see Grabka and Frick 2012 who recently provide such results for Germany from 1993 to 2008. The individual situation including personal a human capital specification (Polachek and Siebert 1999) proved to be a well suited approach for explanation. In addition, many studies showed the importance also of the household and family situation. For a further discussion of the unidimensional income poverty risk in Germany see also Goebel and Grabka 2012.

As to time, the focus of the microeconometric estimation is still on labour supply, on time spent for paid work. However, with the extended household production approach, the household and family situation as well forms the background for the explanation of time use for unpaid work and other household/family/personal activities. This holds for time spent for various leisure activities, which corresponds to a certain extent to our personal genuine leisure time concept.[32] As to time poverty, the rare already mentioned studies (like Vickery 1977, Harvey and Mukhopadhyay 2007, Burchard 2006) focus on univariate explanation but show the importance of both the personal and household/family situation.

Though for unidimensional income and time poverty analyses at least univariate results are available, there is indeed little evidence of the working poor situation, our concern.

Explaining multidimensional time and income poverty, obviously the explanation has to account to both dimensions, time and income in its interdependence. As to the best of our knowledge so far no empirical multivariate analysis to build on is available for the IMD poverty risk and poverty gap in general and for the new minimum 2DGAP of course.

Our overall specification strategy for the explanation of the poverty risk places greater emphasis on market oriented variables, whereas more personal and family related economic and time use variables, which might help to diminish the poverty gap, are tested for the uni- and multidimensional poverty gap. In addition, to aid in interpretation our respective reference category will be a person expected not to be poor.

For the sake of brevity we highlight only some prominent results in particular for our novel approach, the interdependent multidimensional time and income poverty with its IMD poverty risk and the IMD poverty gap as the minimum 2DGAP.We start with the question what drives IMD poverty risk and IMD poverty gap as the minimum 2DGAP. What follows then is the comparison to its unidimensional results.

The respective estimation results of the poverty risks (step 1) and of the poverty gaps are given in Table 6. The unidimensional gaps there are measured as absolute differences between the poverty line and time respective income. The IMD poverty gap is the minimum 2DGAP, the distance c from Figure 3. In sum, the overall goodness of fit of our estimates is highly significant for all three approaches, the time, income and IMD time and income estimation; the significant selectivity bias coefficient (λ) supports our general IMD modelling strategy.

IMD Time and Income Poverty Risk

Personal Situation: The concurrent explanation seems to wipe out significant gender differences. One reason: though each person in a household is considered as a single observation, nevertheless, being poor in the income dimension depends on an equivalized household net income regardless of the single individual's gender. An increased age increases the IMD poverty risk significantly. Though there is a significant negative quadratic term, however, its amount is too small to show an important diminishing non-linear effect. Being a foreigner increases significantly (α=5%) the IMD poverty risk.

Education: Compared to an A-level equivalent education, there is no significant difference to other educational levels. With respect to the income literature, human capital proved to be

[32] See the results in various scientific journals about leisure, e.g. leisure studies and e.g. Merz (1996, 1989) for market and non-market behavioural response of tax reform policies

important, i.e. being active in the labour force, but once an individual was active other variables seem to be more important for explaining the poverty of the working poor.

Occupation: Compared to the reference as a civil servant, a blue collar worker has a significantly higher risk of IMD poverty. With our data base we are able to divide the self-employed into (liberal) professions (freelancers, 'Freiberufler') and entrepreneurs (business-persons, tradesmen, 'Gewerbetreibende') showing different results. In particular, there is a significant risk of being poor for the self-employed as an entrepreneur. This is a remarkable result since common sense tells that the self-employed, regardless of being a (liberal) profession or entrepreneur, will be rich by money and, because of their independence and time sovereignty, will be rich by time, too. For a further in-depth analysis of self-employed poverty see Merz and Rathjen (2011a,b).

Job: As expected, a higher individual wage diminishes the poverty risk significantly, and it is rather the wage than the number of weekly working hours which is the driving factor behind the income situation. However, the *daily* working hour arrangement – testable because of the time diary information with its ten-minute activity slots – is important for the poverty risk situation: Compared to a normal non-fragmented full-time job, flexible working hours significantly increase the poverty risk. In particular, fragmentation and a job outside core hours (7 am to 5 pm) increase the risk of poverty. [33]

Family/Household: An increasing number of children for couples and for single parents increase significantly the IMD poverty risk compared to the better situated couples with no children. Thus, any anti poverty policy has to take into account particularly child targeted issues.

Economic Branch: Compared to the most prevalent service industry, agricultural work increases significantly the IMD risk of time and income poverty. Working in the industrial sector yields a better situation but only significant with α=6.6%.

Region: Finally, even more than ten years after the German reunification, living in eastern Germany is highly significant in increasing the overall risk to be IMD poor.

To summarize the IMD poverty risk results: Personal (but not gender) and the family situation together with education, occupation and in particular the job situation with its daily working hour arrangements including the branch and regional characteristics proved to play an important role in Germany 2001-02 in explaining the risk of multidimensional (IMD) time and income poverty.

IMD Time and Income Poverty Intensity – Minimum IMD Poverty 2DGAP

The specification strategy for the explanation of the IMD poverty intensity, the multidimensional poverty gap (minimum 2DGAP), in particular will test human capital factors as well as concurrent household time use and further household indicators to explain individual poverty severity and the family situation to escape IMD poverty.

[33] For a further in-depth discussion of flexible daily working hours according to the timing and fragmentation and its significant influence on the income distribution see Merz, Böhm and Burgert 2009.

One overall result is that compared to the explanatory power of our specification of the IMD poverty risk, a relatively small number of significant coefficients are determined to explain the minimum IMD poverty gap (minimum 2DGAP) (Table 6).

Personal and Human Capital: While no visible gender differences can be attributed to the household based income poverty threshold definition, there are fewer than expected individual genuine leisure time differences between males and females. Nevertheless as further descriptive results show, the unidimensional time poverty risk for women (50.9%) is larger than for men (45.3%). An engagement for others measured as time spent actively helping others is not significant. Age influences additional to the human capital years of schooling and working experience are not significant. Again, although human capital in many studies is found to be an important indicator to explain labour supply, it turns out that once being working poor the multidimensional poverty gap is not affected.

Occupation: Not only the risk to be IMD poor but also its poverty intensity is in particular driven by the self-employed as liberal professions and entrepreneurs. The labour market situation with outsourced small businesses, hard situations for many freelancers, increasing time stress in particular for the self-employed seems to be remarkably strong so that it outweighs the prosperous self-employed. As further results support the findings, the higher income inequality among the self-employed in Germany is not driven only by the very rich, but also by a relatively large group of low income self-employed.[34]

Job: Beyond the significant wage, IMD poverty intensity is not further influenced significantly by further daily working hour arrangements. Though the IMD poverty risk depends on those paid working time variables, the resulting poverty gap however does not, although the individual income situation depends on the different daily working hour arrangements (see Merz, Böhm und Burgert 2009).

Family/Household: Being a single parent with more than one child significantly increases the poverty gap; the remaining family/child situations also increase the poverty gap but not at a 5% level of significance. We also test the influence of competing time absorbing household activities, such as for housework and childcare hours, and the specific situation of caring for young children. The result is that only a young child (not yet in school) is binding possible paid working activities and deepening the IMD poverty gap. Help from outside the household (measured in hours), which could liberate resources to reduce IMD poverty intensity, is not significant.

[34] So, based on German individual tax data, e.g. the median income of the self-employed is significantly below the median income of the employees at the time of our analysis (see Merz 2007, 2004, Merz and Zwick 2005). Eardley and Corden 1996 provide a general discussion of low income self-employment.

Table 6: Poverty Risks and Poverty Gaps of Unidimensional Time and Income Poverty and Interdependent Multidimensional (IMD) Poverty, Two-Step Heckman Estimation Results, 2001-02, Germany

	Time				Income				IMD Time and Income			
	Time Poverty Risk		Time Poverty Gap		Income Poverty Risk		Income Poverty Gap		IMD Poverty Risk		Minimum 2DGAP (c)	
	Probit		Selectivity corrected OLS		Probit		Selectivity corrected OLS		Probit		Selectivity corrected OLS	
	Coeff.	p-values	Coeff.	p-values	Coeff.	p-values	Coeff.	p-values	Coeff.	p-values	Coeff.	p-values
Personal												
Female	0.304***	0.000	-0.178	0.942	-0.251*	0.017	41.74	0.160	-0.0513	0.391	-2.977	0.637
Age	0.0564***	0.000	3.121	0.704	0.0913**	0.009	-35.21	0.775	0.0992***	0.000	23.45	0.763
Age**2	-0.000641***	0.000	0.0234	0.432	-0.00103*	0.018	0.288	0.326	-0.00122***	0.000	-0.0697	0.304
Married	-	-	2.203	0.554	-	-	51.47	0.051	-	-	11,30	0.197
Active help	-	-	0.0631	0.508	-	-	-0.943	0.371	-	-	-0.0541	0.687
Not German	0.00431	0.978	-6.495	0.334	0.924***	0.001	80.08	0.124	0.445*	0.033	24.56	0.181
Human Capital												
School Years	-	-	-5.003	0.528	-	-	19.45	0.870	-	-	-15.81	0.837
Experience	-	-	-4.409	0.581	-	-	20.59	0.865	-	-	-21.01	0.786
Experience**2	-	-	-0.0178	0.543	-	-	-0.184	0.515	-	-	0.0728	0.258
Education												
A-Level (Ref.)												
Second. School II	-0.0701	0.092	-	-	-0.0243	0.834	-	-	-0.00428	0.943	-	-
Second. School I	-0.0548	0.292	-	-	-0.0846	0.527	-	-	0.0489	0.522	-	-
Still in School	-0.942	0.069	-	-	-5.221***	0.000	-	-	-0.335	0.546	-	-
Occupation												
Civil Servant (Ref.)												
Liberal Profession	-0.0788	0.378	2.904	0.539	0.927**	0.004	41.82	0.519	0.186	0.203	34.98**	0.009
Entrepreneur	0.198*	0.018	9.959*	0.020	0.946**	0.003	104.6	0.099	0.499***	0.000	38.23**	0.001
Blue Collar	0.082	0.257	-2.882	0.427	0.54	0.056	48.1	0.398	0.306**	0.007	9.144	0.254
White Collar	0.116*	0.041	2.023	0.510	0.262	0.346	50.56	0.308	0.138	0.160	4.951	0.475
Other Occupation	0.0624	0.593	0.657	0.920	0.408	0.312	71.26	0.254	0.215	0.192	28.80	0.246
Job												
Wage	0.00288	0.439	-0.288	0.171	-0.152***	0.000	0.837	0.905	-0.0724***	0.000	-3.074***	0.000
Weekly working hours	0.0122***	0.000	0.373***	0.000	-0.0203***	0.000	-0.661	0.612	-0.00226	0.454	-0.353	0.371

Daily work:Core/Fragmented	0.129***	0.001	0.311	0.880	0.142	0.112	-0.644	0.969	0.112*	0.036	1.954	0.664
Non-Core/Not Fragmented	0.589***	0.000	14.50***	0.000	-0.0311	0.868	-28.68	0.643	0.487***	0.000	-5.007	0.515
Non-Core/Fragmented	0.488***	0.000	30.82***	0.000	-0.0736	0.778	21.82	0.652	0.486***	0.000	3.121	0.738
Family/Household												
Couple 0 child (Ref.)												
Couple 1 child	0.0776	0.203	2.811	0.412	0.0784	0.678	-15.01	0.764	0.221*	0.021	-2.731	0.757
Couple 2 children	0.109	0.067	1.248	0.710	0.204	0.275	40.35	0.393	0.456***	0.000	0.868	0.920
Couple >2 children	0.312***	0.000	5.766	0.167	0.941***	0.000	-21.11	0.727	1.016***	0.000	3.352	0.785
Single	-0.00268	0.971	4.944	0.281	0.607**	0.002	76.55	0.116	0.321**	0.005	20.93	0.079
Single 1 child	0.0574	0.512	5.327	0.304	1.111***	0.000	-2.524	0.965	0.788***	0.000	23,10	0.078
Single > 1 child	0.191	0.056	0.778	0.897	1.180***	0.000	87.33	0.206	0.989***	0.000	39.39**	0.008
Other Family Structure	0.173	0.097	3.864	0.464	0.318	0.246	60.34	0.395	0.470**	0.001	27.69	0.169
Housework Hours	-	-	1.924**	0.003	-	-	1.373	0.819	-	-	0.420	0.833
Childcare Hours	-	-	2.255	0.202	-	-	-34.97**	0.005	-	-	-0.836	0.826
Youngest Child <7 years	-	-	-0.406	0.887	-	-	58.85	0.051	-	-	28.80**	0.003
Household Help	-	-	0.011	0.888	-	-	1.467	0.293	-	-	-0.00257	0.986
Branch												
Service												
Agriculture	0.118	0.219	-	-	0.383	0.073	-	-	0.265*	0.039	-	-
Industry	-0.0684	0.136	-	-	0.0817	0.469	-	-	-0.111	0.066	-	-
Region												
Eastern Germany	0.335***	0.000	-1.072	0.649	0.164	0.143	-3.023	0.895	0.263***	0.000	2.002	0.780
Constant	-2.085***	0.000	56.52	0.342	-2.530**	0.002	477	0.569	-3.057***	0.000	-112.9	0.813
Lambda	-	-	-4.226	-	-	-	-48.81*	-	-	-	-21.23**	0.004
n	7,354				7,354				7,354			
Uncensored	3,631				315				946			
Wald chi2(31)	101.34***				67.48***				83,67***			
Log Pseudo Likelihood	-24,098				-2,885				-7,.580			

Std. errors adjusted for 2877 clusters; Significance levels: *=α<5%, **= α<1%, ***= α<0.1%

Source: Own calculations with GTUS 2001-02, active population

Region: Though the risk to poverty is significantly higher in eastern Germany than in western Germany, no such differences can be found in the IMD poverty intensity between the two German regions.

To summarize the IMD poverty gap (minimum 2DGAP) results: Whereas a profound set of explanatory market oriented and non-market household/family factors could be determined for the multidimensional risk of time and income poverty, the set of significant explanatory variables for the multidimensional poverty intensity is remarkably smaller. Many personal (but not gender) and human capital variables, daily working hour arrangements, the children situation (to a certain extent) and the region are not significant. However, further time sensitive activities, such as caring for a young child, the individual wage and remarkably again the self-employed situation of entrepreneurs and liberal professions, do have a significant influence in explaining the multidimensional time and income poverty intensity.

Unidimensional Time and Income Poverty Risks and Poverty Gaps

As for the multidimensional case the unidimensional poverty risk explanation succeeds in explaining the respective unidimensional poverty gap explanation both for time and income (Table 6).

Concerning the poverty risk: With regard to the daily working hour situation fragmentation and the location in core and non-core working hours significantly increase the risk of time poverty but not the risk of income poverty. Single with and without children will rise the income poverty risk but not the time poverty gap. Whereas the time poverty risk is significantly higher in East Germany this is not the case for the income poverty risk.

Concerning the poverty gap: Though for the time poverty gap we find some significant influences of the weekly and daily working hours situation (non-core working hours), yet the explanation of the income poverty gap remains poor.

Since empirical results (multivariate) risk of unidimensional time poverty analyses for Germany from other authors (to the best of our knowledge) are not available, our new results cannot be compared to others. However, our findings (Table 6) that single parents and families with more children in particular are exposed to the risk of income poverty are in some line with recent multivariate results of Grabka and Frick (2012, p. 9). Yet, the results there are not based on the working poor like it is in our case.

To answer the question about different explanations of unidimensional versus multidimensional poverty risk and intensity: Though there are some common patterns in the uni- and multidimensional explanation, like the resounding poverty risk for entrepreneurs or for singles and couples with many children or the absence of human capital and education influences, however, the overall pattern shows a different picture for the unidimensional compared to the multidimensional analysis. And, it is not an additive mix of unidimensional influences which explains the multidimensional case.

5 Further Discussion and Concluding Remarks

This study analyses the intensity of time and income interdependent multidimensional (IMD) poverty and introduces a multidimensional poverty gap, the minimum 2DGAP, which disentangles the single attribute poverty intensities while respecting the attribute's interdependence at the same time (compensation approach).

IMD time and income poverty is measured by a multidimensional Foster-Greer-Thorbecke (FGT) approach, which considers multidimensional well-being units delivering headcount ratios and information about the intensity of the poverty gaps. The interdependence between time and income there is regarded with respect to the union approach (strong focus axiom) and the compensation approach (weak focus axiom), allowing compensation between the dimensions over their whole ranges. With the introduced minimum 2DGAP, a unique projection of interdependent multidimensional well-being (compensation approach) to the two dimensional poverty space, the unidimensional attributes are visible and define an efficient way out of multidimensional poverty.

The application with focus on time and income multidimensional poverty provides a novel contribution to the analysis of the working poor in Germany. To account for Sen's capability approach with its social participation aspects, we define the time dimension as genuine personal leisure time and argue that when this personal time, which remains after all responsibilities (paid work or work and other activities within the family/household etc.) is restricted, then a person should be called poor in the time dimension because of the limited possibilities for social participation.

The IMD poverty threshold with its substitution/compensation trade-off between time and income is first evaluated by the total German population and estimated by a CES well-being function with individual satisfaction information from the German Socio-Economic Panel. The more detailed German Time Use Surveys (GTUS) available for 1991-92 and 2001-02 with its time use diaries then serve to assign an individual to be poor or not for diverse poverty regimes over a ten-year period.

Unidimensional time and income poverty: The *unidimensional income poverty risk slightly but not significantly increases* over the investigated decade in Germany while the *unidimensional time poverty risk* increases significantly for the active population within the ten-year period (headcount ratios). *Unidimensional gap intensity* indices in addition suggest a stronger deprivation in 2002 (significant FGT1), which is however not significant anymore when poverty aversion increases (FGT2).

IMD poverty measured by well-being units: Our interdependent multidimensional poverty results based on multidimensional FGT measures focus on well-being units. *Interdependent multidimensional poverty (union approach, strong focus)* also indicates significantly more frequent IMD poverty in 2002 but indicates a diminished IMD poverty gap when poverty aversion is increased (FGT2).

IMD poverty according to the compensation approach (weak focus), however, is undetermined in the decade's development of the IMD poverty gap though some (not significant) decrease is visible.

One poverty regime is of particular interest. It is the poverty regime where time poverty is assigned and is not to be compensated even by a higher than poverty income. This (Regime 3) group, with a poverty headcount ratio still of 8.7% in 2001-02, is not judged to be poor by the traditional income orientated poverty concepts. However, as this remarkable result indicates, before a background of increasing time squeeze and time stress, society assigns a relatively high value to the time dimension and in particular to personal genuine leisure time with its social participation aspects.

IMD poverty measured by the minimum 2DGAP: Refining the well-being unit approach, our introduced minimum 2DGAP poverty measure crystallizes a unique path out of a fan of paths between the isoquants of different poverty situations. The empirical result of what we

called the efficient way out of multidimensional poverty is that poverty severity increased significantly within the decade from 1991-92 to 2001-02. The disentangled time and income poverty gap attributes are significantly higher in 2001-02; within that decade it is going to be harder to escape multidimensional poverty in both dimensions. This result is different to that of the over time decreasing (but not significantly) IMD poverty gap measured by well-being units (compensation approach, weak focus). From that we may conclude that multidimensional (time and income) poverty should not be neglected as long as both measures are different.

The mean minimum 2DGAP as a summarized description of the multidimensional poverty intensity for Germany has its starting point in the core poverty regime (R1), highlighting the particular importance of the poverty intensity of the working poor who are time *as well* income poor.

What drives Time and Income Uni- and Multidimensional Poverty – Poverty Risk and Poverty Gap Microeconometric Estimation: Whereas a profound set of explanatory market oriented factors (like daily working hour arrangements and, in particular and unexpectedly, being a entrepreneur) as well as non-market household/family factors (like the family situation with children) were identified that increase the multidimensional risk of time and income poverty, the set of significant explanatory variables for the multidimensional poverty intensity is smaller. Many personal (but not gender) and human capital variables, daily working hour arrangements, some family variables and the region are not significant to explain the minimum 2DGAP. However, further time sensitive activities with caring for a young child, the single parent situation with more than one child, and, remarkably and again, the self-employed situation of entrepreneurs and liberal professions significantly deepens the multidimensional time and income poverty intensity.

The emerging question about different explanations of unidimensional versus multidimensional poverty risk and intensity is to be answered as follows: Though there are some common patterns in the uni- and multidimensional explanation, like the resounding poverty risk for entrepreneurs or for singles and couples with many children or the absence of human capital and education influences, however, the overall pattern shows a different picture for the unidimensional compared to the multidimensional analysis. And it is not an additive mix of unidimensional influences but an explanation of its own which characterizes the multidimensional case

Since our (multivariate) analyses and results (besides the unidimensional poverty risk) are novel for Germany any comparison with the literature are not yet possible. This holds not only for the general approach of time poverty and the interdependent multidimensional time and income poverty, but the more for the working poor, our group of interest.

Since the uni- and multidimensional time and income *poverty gap* explanation by far could not be as good as for the respective *poverty risk* explanation further research is certainly needed. Since our data base (as many others) focus on the individual personal and household situation, conceivable influences to individual poverty from the regional economic situation, the regional unemployment rate and further labour market rigidities and conditions are not testable. Obviously further empirical research should enhance the analyses by such factors providing deeper insights in particular for the interdependent time and income situation.

It is almost needless to say that although a measure like the minimum 2DGAP will indicate an efficient way out of poverty, real life conditions may restrict such a possibility to overcome poverty. Nevertheless in pinpointing differences between poverty situations a unique description is provided.

All empirically based results indicate the overall importance of the time dimension with its social participation aspect and that it should be incorporated in an interdependent multiple time and income poverty approach. As to the German population evaluation, time is so valuable that a remarkable proportion of the working population would not compensate their time deficit even by above poverty income.

Any targeted policy for reducing poverty would ignore an important dimension if time with its social exclusion aspects would be neglected. Beyond income policies for the working poor (such as a minimum wage or other labour market policies), particular time policies are also required for a better and more efficient synchronization of working and non-working time consuming activities (flexible working hours, commuting and public transport, childcare support, parental leave conditions, coordinated public services, etc.) in general and in particular to reduce multidimensional poverty while supporting social participation.

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